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AGRICULTURAL LIME ANALYSES

H. J. PATTERSON, President

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Chemical Department, Maryland Agricultural College

COLLEGE PARK, MD.

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ANALYSES OF

Agricultural Lime Sold in Maryland

BY THE CHEMICAL DEPARTMENT OF

The Maryland Agricultural College

Dr. H. B. McDonnell, Professor of Chemistry,—State Chemist.
L. B. Broughton, M. S., Assistant Professor of Chemistry.
T. D. Jarrell, B. S., First Assistant Chemist.
A. C. Adams, B. S., Assistant Chemist.
Alfred Nisbet, Assistant Chemist.
Arthur M. Gibson, Assistant Chemist.
F. G. Baggs, Clerk.

On the following pages are the results obtained in the inspection and analysis of agricultural lime under the new law which became effective in June, 1912. While great care has been exercised to get reliable and average samples, it must be remembered that such materials are not uniform from time to time, and even in the same lot there will be a great variation in the analysis of different pieces. This is well illustrated by a sample sent to the laboratory as a fair sample of the output of a certain lime kiln. The sample consisted of two lumps of lime, each weighing about four ounces. These lumps were analyzed separately, with the following result, in per cent. or parts per hundred:

	Lime.	Magnesia.	Insoluble.
No. 1.....	98.31	0.60	0.38
No. 2.....	60.69	3.01	20.53

Such material is best sampled at the time of loading or unloading a car, by taking a shovelful from each cartload and placing them in a pile in a clean place, giving a sample of at least a bushel, and, preferably, several bushels. The larger lumps are then broken, the pile well mixed and cut in the middle, discarding one-half. The other half is worked over again in the same way and the process repeated till a sample of a gallon or two obtained with no lumps larger than a small chestnut and the final sample of about a quart drawn from this. The great care required in all sampling is something that only those with special training in the matter can appreciate.

In view of the difficulty in sampling and the cost of analysis, this department cannot undertake to analyze samples sent in unofficially.

In addition to the difficulty of proper sampling, it should be remembered that lime takes up moisture and carbonic acid from the air, thus increasing its weight and lowering the percentage of lime. The difficulty of sampling ground limestone and ground oyster shell is much less and the material is fairly stable.

Action of Lime. The action of lime may be quite complex, but the most important action is to neutralize acid in the soil, both organic acid produced by decay, and nitric acid, which is produced by the process called "nitrification," which is very important to the growth of plants. In this process if the nitric acid is not neutralized by lime or some other base as it is formed the minute organisms that produce the change are destroyed and the process stops. While lime is of great importance in agriculture, and much more of it could be used with profit than is now used, it has its own place and will not take the place of manure or fertilizers, except as it promotes the growth of clovers and other legumes which draw nitrogen from the air and store it up in the soil, in this way taking the place, to a considerable extent, of nitrogenous (ammoniated) fertilizers.

Sources of Lime. The principal sources of lime are limestone and oyster shells. Both are carbonate of lime, and by heating to a high temperature called "burning," the carbon dioxide or "carbonic acid gas" is driven off and the oxide of lime remains.

Limestone varies much in composition, some being almost pure carbonate of lime, others containing considerable amounts of magnesia. It also contains more or less sand, silicates, etc., most of which is shown in the tables as "insoluble matter." This sand, etc., not only reduces the percentage of lime and acts as a "filler," but renders the lime liable to melt or form clinker in burning. Such overburned lime is worthless. Pure lime cannot be melted and cannot be overheated in burning.

Oyster shells are nearly pure carbonate of lime. In practice, however, oyster shells will contain from 100 to 200 pounds of sand, etc., per ton. 100 pounds of pure carbonate of lime will give 56 pounds of pure lime (quick lime) when perfectly burned, and this, by the addition of the proper amount of water will be slaked or hydrated to 76 pounds of hydrated lime. In practice, however, there is some excess of water used in hydrating, without making the product wet, and the yield would be without 80 pounds, or a little more. (For comparisons see table below.)

Recently much ground limestone and ground oyster shell has been used instead of the burnt lime, and its use is on the increase. It is frequently a by-product where limestone is crushed for road-making or other use, or oyster shells are ground for poultry. It should be remembered that about twice as much is required as of quick lime, and that it should be finely ground. It is desirable that three-fourths, or 75 per cent should pass through a 100-mesh sieve. That is, a sieve with 100 wires to the linear inch. As the wire occupies about half the space, such a sieve has openings about 1-200th of an inch in diameter. That which will not pass through a 20-mesh sieve is of little or no value.

The table of mechanical analysis shows the fineness of ground stone and shells by using a series of sieves as indicated.

Kind of Lime to use. With the various products now on the market—lump lime, oyster shell lime, ground lime, ground limestone, ground oyster shell, hydrated lime, etc.—it is frequently very confusing to the farmer as to what to use. However, this is a question that will, to a considerable extent, have to be solved by the user, as each kind has its advantages and disadvantages, and the final advantage as to relative cost will often depend on the locality.

Weight for weight stone lime and shell lime are about equally efficient and the only fair basis of comparison is by weight. When sold by the bushel, lime should be rated at 80 pounds to the bushel. However, stone lime will weigh more than this, as a rule, while oyster shell lime will weigh much less per measured bushel.

Some of the advantages of lump lime are its greater concentration, so that not so much is required; saving in freight and handling; saving bags, as it is generally shipped in bulk. Some disadvantages are: that it must be slaked before spreading, involving additional work; and that it is very disagreeable material to handle, so that the workmen object to handling it.

Ground lime has, of course, the same composition as the lump lime, being the latter ground in a mill. It is ready for application without any preliminary treatment and may be applied with a drill with the proper attachment. It slakes in intimate contact with the soil and gives the maximum effect. It requires bags in shipping; will soon air-slack and burst the bags; it is disagreeable to handle and costs more than the lump lime.

Ground limestone and oyster shell is comparatively cheap, especially when obtained as a by-product. If finely ground it is quite efficient when applied in twice the amount that would be used of quick lime. It is comparatively pleasant to handle and will not injure seeds or plants if in direct contact and an excess of it will do no harm. Some of its disadvantages are that twice the amount is required, increasing freight and handling bills, and that, frequently, it is not ground fine enough to give proper results. As stated above, 75 per cent of ground stone or shell should pass a 100-mesh sieve and practically none should be coarser than 20-mesh.

Magnesia. Most limestone contains appreciable amounts of magnesia and some limestone contains a large amount—nearly as much magnesia as lime. In the stone it is present as the carbonate. It is quite similar in its properties and action to lime. When it is heated the carbonic acid is given off as a gas and the oxide, called magnesia, is left, associated, of course, with the lime oxide or lime. Magnesia oxide hydrates or slakes much slower than lime and the hydrate is less soluble in water. However, it is somewhat more efficient in neutralizing acid and experimenters generally agree that it is equally as efficient as lime for agricultural purposes. In making comparisons, therefore, the lime (oxide of lime, CaO) and magnesia (oxide of magnesium, MgO) should be added and the sum used in comparisons.

Lime, quicklime, oxide of lime, calcium oxide, etc., is always made by "burning" some form of carbonate of lime, as limestone, marble or shells. A common but crude form of limekiln for preparing lime consists of a pile of wood, or wood and coal mixed, on top of which is piled the limestone or shells and the fuel is then burned, heating the carbonate of lime and converting it to oxide of lime. This method is very wasteful of fuel and generally leaves a part of the carbonate unchanged.

Better results are obtained by some form of permanent kiln. In this the limestone and fuel are enclosed by a wall of stone or brickwork, which aids the burning and helps to retain the heat. Permanent kilns are generally made to work continuously by adding limestone and fuel alternately at the top and drawing off the lime at the bottom. In all of the above methods the lime is more or less contaminated with the ashes and unburned part of the fuel which remain mixed with it.

This may be avoided by arranging the furnace to one side of the kiln so that only the flame and hot gases come in contact with the lime and limestone, the fuel and ashes being kept separate.

Hydrated Lime, Slack Lime. Lime (quicklime) combines with water to make hydrated lime (slaked or slacked lime). Hydrating machines are now in use that are quite efficient, adding only the proper amount of water and sifting out the impurities, so that the product is all a fine, dry powder. Some lime will slake very rapidly, while others are very slow. Magnesia, when present in considerable quantity, retards slaking. Rapid slaking generates much heat so that wood in contact with slaking lime may be set on fire. For this reason lime in bulk is not shipped by water.

Lime will also combine with the water in the air in the form of vapor, taking it up forming air-slacked lime. Hydrated lime also combines with the carbonic acid gas or carbon dioxide, which is present in the air in small amount, forming carbonate of lime, some of which is always present in air-slacked lime. This is what takes place in the process of hardening of mortar. The process is necessarily very slow when the lime is in bulk, but comparatively rapid when it is spread out in thin layers, as it is after application to the soil, or as whitewash. High heat will convert both the carbonate and hydrate back to the oxide form, with corresponding loss in weight. The corresponding compounds of magnesia act in the same way.

When these changes take place there is a change in weight of the residue in every case, and this, in the case of the perfectly pure substances, takes place in the proportions shown in the following table, in which the figures are percentages or pounds in a hundred. It should be remembered that the power to neutralize acid depends on the amount of oxide of lime (and magnesia) present in any case.

Table I showing equivalents.

Names and Sources of Lime	100 lbs. is equivlant to or will make		
	Oxide of lime CaO	Hydrated or slaked lime $Ca(OH)_2$	Carbonate of lime $CaCO_3$
Lime, Quick lime, from limestone or oyster shells by heating to a high ing temperature	100	132	179
Hydrated lime—Slaked lime, by add-water to quick lime	76	100	135
Carbonate of lime,—Limestone, oyster shells, gas lime	56	74	100

The number of pounds on each horizontal line are equivalent, chemically, and have equal power to neutralize acid. Thus, 100 pounds of oxide of lime will neutralize as much acid as 132 pounds of dry hydrated lime or 179 pounds of carbonate of lime. As stated above, however, the general rule is to use twice as much carbonate of lime as would be used of oxide. These facts should be borne in mind when comparing prices.

Gas Lime. Much slaked lime—in this vacinity generally from oyster shells—was formerly used at gas works to purify illuminating gas. While this method of purification is not now in use, there are still large accumulations of the old gas lime available. As it has been exposed for many years, it is generally rather wet. However, it is sometimes dried, or dried and sifted, before being sold. The pile would contain about 30 per cent. of oxide of lime. Sample No. 3, in the following table, is gas lime that has been dried and sifted. The lime in gas lime is nearly all in the form of carbonate of lime. Being formed by the action of carbonic acid on the hydrate, the particles are rather fine—in fact, it is similar to the "precipitated chalk" of the druggist, only not so pure.

Plaster (Land Plaster) is a natural mineral or rock called "gypsum," ground to a fine powder. It generally is imported from Nova Scotia, though there are deposits in various parts of the United States. It is comparatively soft rock and is silghtly soluble in water. It is prepared for the market by grinding. It is a natural sulfate of lime with crystal water (chemical formula is $CaSO_4$-$2H_2O$). The perfectly pure compound contains 32.5 per cent of oxide of lime. However, this lime, being already in combination with the strong acid, sulfuric (commonly called oil of vitriol), will not neutralize any more acid, its action being different from the forms of lime discussed above.

As the most common impurity in plaster is carbonate of lime (which contains 56 per cent. of oxide of lime), most of the analyses of commercial plaster will shown more oxide of lime than 32.5 per cent., which is the amount of lime in pure gypsum. Plaster may be

made artificially by the action of sulfuric acid on lime, or most compounds of lime, the sulfuric acid displacing most other acids. This takes place in dissolving phosphate rock with sulfuric acid to make the ordinary dissolved rock, more than half of which is plaster formed in the process of manufacture.

The tables following give the results of analysis of official samples under the lime law. It should be remembered that other samples will be expected to show more or less varying results, so that these figures should not be taken as conclusive. The tables only show the essential part of the composition, as it will be seen that none of them add up to 100 per cent. It is often asked of what does the balance consist? In the case of burnt lime, the part not given is comparatively small and consists of a little carbonic acid gas, water of combination due to the beginning of air-slaking, a little oxide of iron and alumina, etc. In the case of hydrated lime there is in addition a considerable amount of combined and some free water. In the case of ground limestone or shells the amount of carbonic acid gas in combination is between 40 and 50 per cent. (see Table I.)

Purchasers of lime are urged to demand a guarantee, including a statement, as to the kind of lime.

For additional information, regarding lime, methods of application, results of experiments, etc., see Bulletin No. 110, of the Maryland Agricultural Experiment Station.

ANALYSES OF LIME.

No.	Name of Manufacturer or Agent.	Name of Lime or Kind.	Place of Sampling.	Lime Oxide CaO		Magnesia Oxide MgO		Sand & Insoluble (of no value)	
				FOUND.	Guaranteed.	FOUND.	Guaranteed.	FOUND.	Guaranteed.
54	American Agr'l Chemical Co., New York, N. Y.	Fine Ground Nova Scotia Land Plaster	Baltimore.....	37.46		.28		1.74	
2	Atlantic Fertilizer Co., Baltimore, Md.	Pure Nova Scotia Land Plaster.	Baltimore.....	33.93		.18		.57	
3	Baltimore Lime Products Co., Baltimore, Md.	Lime Carbonate.....	Baltimore.....	49.50	48.00	50		5 20	
21	J. E. Baker & Co., York, Pa.	Agricultural Lime.....	White Hall....	51.50		8.37		30.21	
69	" " "	Empire Lump Lime....	York, Pa.....	93.90		3.11		.35	
68	" " "	*Ground Limestone.....	York, Pa.....	48.03		6.84		3.05	
70	" " "	Victor Lime.....	York, Pa.....	55.61		40.02		2.23	
45	S. W. Barrick & Son, Woodsboro, Md.	Agricultural Lump Lime	Woodsboro ...	75.56		11.25		2.51	
40	" " "	Burnt Stone Lime.....	Westover	75.09		4.29		3.66	
5	" " "	H.G. Ground Agr'l Lime	Westover	68.90		4.09		10.69	
4	" " "	Hydrated Lime.....	Manokin	71.90	52.00	5.01		6 41	
41	" " "	Hydrated Lime...	Woodsboro	56.07		8.01		7 59	
80	Herbert Bryant's Son, Alexandria, Va.	*Ground Oyster Shell...	Travilah.....	47.29		.76		9.01	
49	G. M. Bushey & Son, Cavetown, Md.	Agricultural Lump Lime	Cavetown	74.71		9.44		.58	
56	G. &W. H. Corson, Plymouth Meeting, Pa.	Prep. Lime (Hydrated)	PlymouthMeeting, Pa	42.84		30.22		1.33	
57	" " "	Quick Lime.....	PlymouthMeeting, Pa.....	57.11		40.98		.55	
28	Dittman Co., Texas, Md.	Blue Alum Lime,.....	Texas.....	75.36		12.42		7.91	
29	" " "	White Alum Lime.....	Texas.....	93.26		1.89		2.06	
66–7	Emig Lime Co.. Hellam, Pa.	Agricultural Lime.....	Hellam, Pa....	74.50		1.81		10.46	
7	Fountain Rock Lime Co., Woodsboro, Md.	Agricultural Lump Lime	Fountain Rock.	92.15		.85		.67	
8	" " "	Ground Agr'l Lime.....	Fountain Rock.	71.62	85.00	4.64		6.92	
9	" " "	Hydrated Lime.....	Fountain Rock.	50.01	52.00	7.04		9.01	
10	Rob. S. Green, Baltimore, Md.	Ground Limestone.....	Baltimore	54 35		2.69		.25	
50	" " "	Shell Lime.....	Frederick Road	58.47		.43		4.01	
14	Griffith & Boyd Co. Baltimore, Md.	Pure Nova Scotia Land Plaster.	Baltimore	37.17		.00		2.06	
44	M. J. Grove Lime Co. Frederick, Md.	Agricultural Lump Lime	Frederick.....	74.23		12.12		8.61	
12	" " "	Famous Frederick Co. Ground Lime	Rockville.....	59.05		7.20		15.71	

14	Griffith & Boyd Co. Baltimore, Md.	Pure Nova Scotia Land Plaster.	Baltimore.....	37.17		.00		2.06
44	M. J. Grove Lime Co. Frederick, Md.	Agricultural Lump Lime	Frederick.....	74.23		12.12		8.61
12	" " "	Famous Frederick Co. Ground Lime	Rockville.....	59.05		7.20		15.71
13	" " "	Stone Lime.....	Laurel.....	50.37		18.37		9.58
15	Home Fert. & Chemical Co. Baltimore, Md.	Climax Hydrated Lime.	Baltimore.....	71.65		1 63		1 50
16	Hubbard Fert. Co., Baltimore, Md.	Nova Scotia Land Plaster	Baltimore.....	33.20		.00		.86
53	Hudson Cement & Supply Co., Baltimore, Md.	Hydrated Lime.....	Baltimore.....	71.27		1.42		1 65
17	A. M. Isanogle, Thurmont, Md.	Agricultural Lump Lime	Lewistown....	55.12		37.89		.52
19	O. J. Keller Lime Co., Buckeystown, Md.	Stone Lime.....	Laurel.....	74.29		2.25		3.56
20	D. C. Kemp Lime Co., Frederick, Md.	Agricultural Lump Lime	Frederick.....	83.45		3.40		5.86
23	King Lime Co., Legore Md.	Hydrated Agr'l Lime...	Legore.....	60.20		3.11		6.08
24	J. W. Legore Lime Co., Legore, Md.	Agricultural Lime.....	Legore.....	95.88		.85		.83
46	" " "	Agricultural Lump Lime	Legore.....	89.57		1.85		1.89
33	" " "	Refined Hydrated Lime.	Sparks.....	56.10		3.92		4.62
30	Wm. P. Lindsay, Texas, Md.	Agricultural Lime.....	Texas.....	92.30		1.32		4 81
60	M. C. McAleer, Walkersville, Md.	Agricultural Lump Lime	Walkersville...	83.94		2.36		4.56
78	Merion Lime & Stone Co., Norristown, Pa.	Hydrated Lime.....	Norristown, Pa.	47.45		34.17		.67
79	" " "	Run of Kiln Lime.....	Norristown, Pa.	57.81		41 08		.96
55	Moore & Pendelton, Westover, Md.	*Ground Oyster Shell ..	Westover.....	51.07		.47		4.77
76	" " "	Pulverized Oyster Shell Lime	Westover.....	52.36	50.00	45		3.57
82	S. S. Orr, Frederick, Md.	Agricultural Lump Lime	Frederick.....	88.86		3 81		1.51
61	Lowell M. Palmer, York, Pa.	Challenge Brand Hydrated Lime	York, Pa.....	72.46	65.00	1.89		.34
62	" " "	*Ground Lime Stone ..	York, Pa.....	52 16	50 00	3 65		.29
25	Peerless Oyster Co., Baltimore, Md.	Fine Ground Oyster shell	Baltimore.....	48.89		.39		7.54
26	" " "	Slacked Oyster Shell...	Baltimore.....	63.29	37.00	.53		3.22
22	M. B. Price, Cockeysville, Md.	Agricultural Lime.....	Cockeysville...	91.55		1.48		1 60
52	M. P. Price, Texas, Md.	Alum Lime Air Slack...	Baltimore.....	54.59		8.82		5.72
51	Products Sales Co., Baltimore, Md.	Agricultural Lime	Govanstown...	66.04		2 59		1.69
27	" " "	Porcco Hydrated Lime.	Clarksville.....	67.57		3.05		1 41
47	D. F. Roddy, Emmitsburg, Md.	Agricultural Lump Lime	Emmitsburg...	78.21		5 55		4.58
34	Gilmer Schley, Frederick, Md.	Agricultural Lump Lime	Frederick	59.56		33.92		.64
31	Security Cement & Lime Co., Baltimore, Md.	Hydrated Lime.....	Chewsville	69.50	70 00	1.43	2.00	.33

*For mechanical analysis see page 11.

ANALYSES OF LIME.

No.	Name of Manufacturer or Agent.	Name of Lime or Kind	Place of Sampling.	Lime Oxide CaO		Magnesia Oxide MgO		Sand & Insoluble (of no value)	
				FOUND.	Guaranteed.	FOUND.	Guaranteed.	FOUND.	Guaranteed.
35	Standard Lime & Stone Co., Baltimore, Md.	Agricultural Land Lime.	Buckeystown.	91.41	90.00	3 50		.16	
48	" " "	Agricultural Lump Lime	Buckeystown..	84.80	90.00	2.41		3.67	
36	" " "	Baker's Hydrated Lime	Clarksville.....	67 25	60.00	6.52		.53	
81	" " "	*Standard Ground Limestone.	College Park..	53.84	50.00	1.16		1.87	
77	Steacy & Wilton Co., Wrightsville, Pa.	Stone Lime.....	Lineboro	91.21	50.00	5.11		2.07	
63	Tabler Lime & Stone Co., Frederick, Md.	Agricultural Lump Lime	Frederick.....	71.59		6.10		12 04	
37	" " "	Agricultural Lump Lime	Frederick.....	70 72		5.57		8.32	
64	" " "	Ground Agr'l Lime.....	Frederick.....	66.09		3.42		8 37	
59	Talbot Mfg. Co., St. Michaels Md.	*Ground Oyster Shell...	Salisbury.....	46.17		.46		13.33	
32	Tidewater Portland Cement & Lime Co., Union Bridge, Md.	Hydrated Lime.....	Taneytown....	71 56	75.50	1.73	1.50	1.76	
1	W. H. Valliant & Bros., Bellevue, Md.	Ground Oyster Shell....	Bellevue.....	49 34		.66		5 87	
71	Chas. Warner Co., Wilmington, Del.	Ground Lime.	WilmingtonDel	55.51		40.93		2.22	
72	" " "	*Ground Lime Stone...	WilmingtonDel	29.57		21.81		2.95	
73	" " "	Hydrated Lime.....	WilmingtonDel	47.54		34.87		1.70	
42	Washington Building Lime Co. Buckeystown, Md.	Lump Lime.....	Frederick Road	80.14		1.41		4.33	
58	West River Oyster & Lime Co. Baltimore, Md.	Oyster Shell Lime.....	Baltimore	62.98		.70		8.03	
43	Whitehall Agricultural Co., Martinsburg, W. Va.	Slacked Lime.....	Baltimore	72 08	72.00	1 43	2.00	.05	
38	W. M. Widmeyer, Hancock, Md.	Agricultural Lime.....	Hancock	82.91		1.71		2.86	
75	G. W. Woolford & Co., Cambridge, Md.	Hydrated Oyster Shell Lime.	Cambridge	57.09		.70		7.62	
65	York Valley Lime Co., York, Pa.	Agricultural Lime.....	York, Pa.....	85.25		9.40		1.88	

*For mechanical analysis see page 11.

Pa.

*For mechanical analysis see page 11.

TABLE III—SHOWING MECHANICAL ANALYSIS OF GROUND LIME STONE AND GROUND OYSTER SHELL.

For the Chemical Analysis of these samples see preceding table.

Figures are percentages or pounds per hundred.

No.	Name of Manufacturer or Agent	Name of Lime or Kind	Finer than 100 mesh	Bet. 80 and 100 mesh	Bet. 60 and 80 mesh	Bet. 40 and 60 mesh	Bet. 20 and 40 mesh	Coarser than 20 mesh
68	J. E. Baker Co., York, Pa.	Ground Lime Stone.....	53	4	2	7	12	22
80	Herbert Bryant's Son Alexandria Va.	Ground Oyster Shell.....	30	11	8	23	27	1
55	Moore & Pendleton, Westover, Md.	Ground Oyster Shell.....	13	8	14	12	13	40
62	Lowell M. Palmer, York, Pa.	Ground Lime Stone.....	60	10	4	8	9	9
81	Standard Lime & Stone Co., Baltimore, Md.	Standard Ground Limestone	73	16	5	5	1	0
59	Talbot Mfg. Co., St. Michaels, Md.	Ground Oyster Shell.....	29	12	10	22	26	1
72	Chas. Warner Co. Wilmington, Del	Ground Limestone.....	77	7	3	5	6	2

Note—For text of the Lime Law see Quarterly No. 56, May 1912.

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